CLAIMS

We claim:

1. An apparatus for block coding of windows of digitally represented images comprising a chain of lattices of lapped transforms with dyadic rational lifting steps.

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2. An apparatus for coding, storing or transmitting, and decoding M x M sized blocks of digitally represented images, where M is ~~a power of 2~~ an even number, comprising

    a. a forward transform comprising

        i.   a base transform having M channels numbered 0 through M-1, half of said channel numbers being odd and half being even;

        ii.   an equal normalization factor in each of the M channels selected to be dyadic-rational;

        iii.   a full-scale butterfly implemented as a series of lifting steps with a first set of dyadic rational coefficients;

15   iv.   M/2 delay lines in the odd numbered channels;

        v.   a full-scale butterfly implemented as a series of lifting steps with said first set of dyadic rational coefficients; and

        vi.   a series of lifting steps in the odd numbered channels with a second specifically selected set of dyadic-rational coefficients;

20 b. means for transmission or storage of the transform output coefficients; and

    c. an inverse transform comprising

14

i.   M channels numbered 0 through M-1, half of said channel numbers being odd and half being even;

ii.   a series of inverse lifting steps in the odd numbered channels with said second set of specifically selected dyadic-rational coefficients;

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iii.   a full-scale butterfly implemented as a series of lifting steps with said first set of specifically selected dyadic-rational coefficients;

iv.   M/2 delay lines in the even numbered channels;

v.   a full-scale butterfly implemented as a series of lifting steps with said first set of specifically selected dyadic-rational coefficients;

10

vi.   an equal denormalization factor in each of the M channels specifically selected to be dyadic-rational; and

vii.   a base inverse transform having M channels numbered 0 through M-1.

3. The apparatus of Claim 2 in which the normalizing factor takes the value 25/16 and

15   simultaneously the denormalizing factor takes the value 16/25.

4. The apparatus of Claim 2 in which the normalizing factor takes the value 5/4 and simultaneously the denormalizing factor takes the value 4/5.

5. The apparatus of Claim 2 in which the first set of dyadic rational coefficients are all equal to 1.

6. The apparatus of Claim 2 in which the second set of dyadic rational coefficients are all equal

20   to ½.

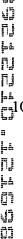7. The apparatus of Claim 2 in which the base transform is any M x M invertible matrix of the

·form of a linear phase filter and the inverse base transform is the inverse of said M x M invertible matrix.

8. The apparatus of Claim 2 in which the base transform is the forward M x M discrete cosine transform and the inverse base transform is the inverse M x M discrete cosine transform.

9. An apparatus for transforming M x M blocks of digital image intensities comprising lapped transforms with overlapping factor K and having butterfly structures and lifting steps to generate M-channel uniform linear phase perfect reconstruction filter banks.

10. The apparatus of Claim 9 in which K equals 2.

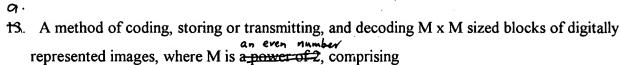11. An apparatus for coding, compressing, storing or transmitting, and decoding a block of M x M intensities from a digital image selected by an M x M window moving recursively over the image, comprising:

a. an M x M block transform comprising:

    i.   an initial stage

    ii.   a normalizing factor in each channel

b. a cascade comprising a plurality of dyadic rational lifting transforms, each of said plurality of dyadic rational lifting transforms comprising

    i.   a first bank of pairs of butterfly lifting steps with unitary coefficients between adjacent lines of said transform;

    ii.   a bank of delay lines in a first group of M/2 alternating lines;

    iii.   a second bank of butterfly lifting steps with unitary coefficients, and

16

    iv.　　a bank of pairs of butterfly lifting steps with coefficients of 1/2 between $M/2 - 1$

        pairs of said $M/2$ alternating lines;

  c.　means for transmission or storage of the output coefficients of said $M \times M$ block

    transform; and

5   d.　an inverse transform comprising

    i.　　a cascade comprising a plurality of dyadic rational lifting transforms, each of said

        plurality of dyadic rational lifting transforms comprising

        a)　a bank of pairs of butterfly lifting steps with coefficients of 1/2 between said

          $M/2 - 1$ pairs of said $M/2$ alternating lines;

10   b)　a first bank of pairs of butterfly lifting steps with unitary coefficients between

          adjacent lines of said transform;

        c)　a bank of delay lines in a second group of $M/2$ alternating lines; and

        d)　a second bank of pairs of butterfly lifting steps with unitary coefficients

          between adjacent lines of said transform;

15   ii.　　a de-scaling bank; and

    iii.　an inverse initial stage.

12.　A method of block coding windows of digitally represented images comprising successive

    steps of processing the output of each step through a following step in a chain of lattices of

    lapped transforms with dyadic rational lifting steps.
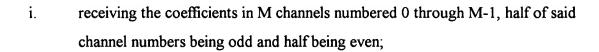
17

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13. A method of coding, storing or transmitting, and decoding M x M sized blocks of digitally
represented images, where M is a power of 2 ~~an even number~~, comprising

    a. transmitting the original picture signals to a coder, which effects the steps of

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        i. converting the signals with a base transform having M channels numbered 0
through M-1, half of said channel numbers being odd and half being even;

        ii. normalizing the output of the preceding step with a dyadic rational normalization
factor in each of said M channels;

        iii. processing the output of the preceding step through two lifting steps with a first
set of identical dyadic rational coefficients connecting each pair of adjacent
numbered channels in a butterfly configuration;

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        iv. transmitting the resulting coefficients through M/2 delay lines in the odd numbered
channels;

        v. processing the output of the preceding step through two inverse lifting steps with
the first set of dyadic rational coefficients connecting each pair of adjacent
numbered channels in a butterfly configuration; and

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        vi. applying two lifting steps with a second set of identical dyadic rational coefficients
connecting each pair of adjacent odd numbered channels to the output of the
preceding step;

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    b. transmitting or storing the transform output coefficients;

    c. receiving the transform output coefficients in a decoder; and

    d. processing the output coefficients in a decoder, comprising the steps of

18

i.   receiving the coefficients in M channels numbered 0 through M-1, half of said channel numbers being odd and half being even;

ii. applying two inverse lifting steps with dyadic rational coefficients connecting each pair of adjacent odd numbered channels;

iii. applying two lifting steps with dyadic rational coefficients connecting each pair of adjacent numbered channels in a butterfly configuration;

iv. transmitting the result of the preceding step through M/2 delay lines in the even numbered channels;

v.   applying two inverse lifting steps with dyadic rational coefficients connecting each pair of adjacent numbered channels in a butterfly configuration;

vi. denormalizing the result of the preceding step with a dyadic rational inverse normalization factor in each of said M channels; and

vii. processing the result of the preceding step through a base inverse transform having M channels numbered 0 through M-1.

14. A method of coding, compressing, storing or transmitting, and decoding a block of M x M intensities from a digital image selected by an M x M window moving recursively over the image, comprising the steps of:

a. Processing the intensities in an M x M block coder comprising the steps of:

    i.   processing the intensities through an initial stage;

    ii. scaling the result of the preceding step in each channel;

b. processing the result of the preceding step through a cascade comprising a plurality of

19

dyadic rational lifting transforms, each of said plurality of dyadic rational lifting transforms comprising

    i.   a first bank of pairs of butterfly lifting steps with unitary coefficients between adjacent lines of said transform;

    ii.   a bank of delay lines in a first group of $M/2$ alternating lines;

    iii.   a second bank of butterfly lifting steps with unitary coefficients, and

    iv.   a bank of pairs of butterfly lifting steps with coefficients of $1/2$ between $M/2 -1$ pairs of said $M/2$ alternating lines;

c. transmitting or storing the output coefficients of said M x M block coder;

d. receiving the output coefficients in a decoder; and

e. processing the output coefficients in the decoder, comprising the steps of

    i.   processing the output coefficients through a cascade comprising a plurality of dyadic rational lifting transforms, each of said plurality of dyadic rational lifting transforms comprising

      a) a bank of pairs of butterfly lifting steps with coefficients of $1/2$ between said $M/2 -1$ pairs of said $M/2$ alternating lines;

      b) a first bank of pairs of butterfly lifting steps with unitary coefficients between adjacent lines of said transform;

      c) a bank of delay lines in a second group of $M/2$ alternating lines;

d) a second bank of pairs of butterfly lifting steps with unitary coefficients

between adjacent lines of said transform;

e) a de-scaling bank; and

f. processing the results of the preceding step in an inverse initial stage.

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15. The apparatus of Claim 2, with any approximation of the special constants in this patent filing.